

Map Unit Properties Table

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Development	Hazards	Potential Paleontologic Resources	Potential Cultural Resources	Mineral Specimens	Potential for Karst Issues	Mineral Resources	Recreation Potential	Global Significance	Limits on restoration
HOLOCENE	Eolian deposits (Qe)	Reworked, black, wind-blown sand, largely derived from cinders; usually occurs as local active dune deposits.	Low	Not conducive for permanent development	Dune erosion and movement	None documented	Dry farming ancient fields	None documented	None documented	Sand	Off- road vehicles on sand dunes	Active eolian dunes derived from very recent eruption, nuance of ecosystem	Active dune environment
HOLOCENE	Basalt cinders and spatter (Qsl)	Locally overlies basalt cinder cone and basalt sheet from eruption of Sunset Crater. Consists of alkali olivine basalt with ultramafic xenoliths. Probably a late stage of the Sunset Crater eruption.	Low	Present only locally; too delicate to be developed	Rockfall and landslides	None documented	Corn cob casts in lava flows - ancient offerings to the volcano by native inhabitants	Ultramafic xenoliths	None documented	Cinders, obsidian	Uneven trail base	Contain very recent, fresh volcanic rocks from most recent eruption on Colorado Plateau	Steep slopes and unconsolidated material
HOLOCENE	Alkali olivine basalt cinder cone of Sunset Crater (Qsc); Basaltic pyroclastic sheet from eruption of Sunset Crater (Qsp) , Bonito and Kana- a flows from Sunset Crater (Qsb)	Unit occurs as a widespread blanket of fresh black and subordinate red cinders mantling preexisting landscape. Composition is alkali olivine basalt with locally abundant ultramafic, gabbroic, granulitic, and sedimentary xenoliths. Some cinders are present as a thin discontinuous mantle. Flows generally overlie basalt cinder sheet from eruption of Sunset Crater. A few ultramafic xenoliths are present. Flow surfaces consist of very fresh pahoehoe, slab pahoehoe, and aa. Thickness ranges from 2 m near margins to perhaps 30 m or more in the center of the Bonito flow.	Moderate	Unconsolidated material may be unstable for foundations, especially if a slope is present. Varying permeability may pose a challenge to waste facility development.	Rockfall and landslides, sharp volcanic glass	None documented	Flows and cinders buried pithouses and fields of early native inhabitants, some excavated	Phenocrysts of olivine, clinopyroxene; rare plagioclase; Fumerolic: Gypsum, magnetite, hematite, sulfur, cuprite (?), opal, jarosite, voltaite, ralstonite, alunogen, ilmenite, barite, and celestite	None documented	Sulfur, gypsum	Off- road vehicles on cinders; uneven trail base on lava flows	Contain very recent, fresh volcanic rocks from most recent eruption on Colorado Plateau	Steep slopes and unconsolidated material
HOLOCENE	Alluvium and colluvium (Qal); Terrace gravels (Qtg)	Mostly cinders; in western part unit includes glacial outwash, Sinagua Formation, and dissected alluvial fan deposits on the north side of O'Leary Peak; dissected gravel deposits largely composed of silicic volcanic rock fragments. Gravel terrace remnants cap mesas near the Little Colorado River. Pebbles include silicic volcanic rocks, basalt, granite, quartzite, sandstone, petrified wood, chert, limestone, conglomerate, and arkose.	Low	No restrictions noted, watch for unconsolidated deposits on slopes.	Slumping and slope creep	None documented	Chert and other pebbles may have been used for tool material	Mixed pebbles	None documented	Sand, gravel, clay, silt	Picnic areas and other low impact recreation, no restrictions noted	Records down- cutting by Little Colorado River following uplift of Colorado Plateau	None documented

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PLEISTOCENE	Basalt cinder cones & spatter from vent 127 (Qmc); basalt pyroclastic sheet (Qms); basalt of vent 130 (Qmp); Basalt flows (Qmpv); basaltic andesite cinder and spatter cones (Qmb), Basaltic andesite flows (Qmac); Vitrophyre plugs of O'Neill Crater (vent 109) (Qma); and Strawberry Crater (vent 77) (Qmr)	Includes local spatter and tuff deposits. Composition is generally alkali olivine basalt with minor alkali- rich high- alumina basalt. Cones have sharp rims and are virtually uneroded. Includes little cinder material. Flows are usually black; smooth, relatively uneroded, continuous over large areas; upper part brown because of soil formation. Includes local dune deposits in lee of Woodhouse- and Tappan- age flows. Includes red mantling cinders and basaltic andesite spatter and cinders. Plug- like feature composed of approximately horizontal alkali olivine basalt- flow units that may have been uplifted after ponding in the vent; relatively fresh pahoehoe and aa flows. Scattered ultramafic nodules occur in some flows. Thickness at flow edges ranges from 2 to 12 m. Flows have breached east sides of Strawberry (vent 77) and o'Neill (vent 109) Craters. Apparently extruded as small viscous spines after breaching of the cones by basaltic andesite flows. Chemically, plug of o'Neill Crater is rhyodacite and Strawberry Crater plug is dacite. Inclusions of basaltic andesite spatter occur in the vitrophyre.	Moderate	Unconsolidated material may be unstable for foundations, especially if a slope is present. Varying permeability may pose a challenge to waste facility development.	Rockfall and landslides; sharp volcanic glass in flows and unconsolidated cinder layers	None documented	None documented	Phenocrysts of olivine, clinopyroxene, orthopyroxene, and rare plagioclase, also ultramafic nodules, some volcanic glass locally	None documented	Obsidian	Off- road vehicles on cinders, uneven trail base on lava flows	K- Ar dates include 50,000 +/- 14,000 O'Neill flow and 46,000 +/- 46,000 years for the Strawberry flow (Damon et al., 1974)	None documented
	QUATERNARY	Rhyodacite flow of Deadman Mesa (Qor), Vent facies of rhyodacite flow of Deadman Mesa (Qorr); Rhyodacite dome of Robinson Crater (Qorr)	Plagioclase and orthopyroxene microphenocrysts are scattered in a microcrystalline to cryptocrystalline groundmass. Flow top, which is relatively flat, is largely mantled by alluvium and Sunset Crater cinders. Flow thickness at margin ~90 m. Flow erupted along a fissure marked by reddish oxidation of the rhyodacite and by a steep narrow ridge; includes obsidian and cryptocrystalline to microcrystalline rhyodacite. Dome is mantled by angular fragments. Exposed height of dome ~150 m.	No restrictions noted; volcanic glass present, locally exposed.	Rockfall and landslides; angular fragments	None documented	None documented	Phenocrysts of Fe- olivine & plagioclase; obsidian & pumice common	None documented	Obsidian Pumice	Off- road vehicles unconsolidated rocks	Dating of Deadman Mesa and Robinson Crater	None documented
PLEISTOCENE	Andesite pyroclastic deposits of O'Leary Peak (Qoap); rhyodacite obsidian flow north of O'Leary Peak (Qoo); vent facies of rhyodacite obsidian flow north of O'Leary Peak (Qoov); Rhyodacite porphyry domes of O'Leary Peak (Qord); chaotic rock debris (Qoch); dacite flow north of O'Leary Peak (Qoch)	Red scoria with abundant xenoliths of O'Leary rhyodacite porphyry and quartz xenocrysts and scattered xenoliths of the andesite porphyry flow; occurs as crudely bedded deposits on the south and west flanks of O'Leary Peak. Obsidian is banded and largely devitrified. Flow top consists of frothy, pumiceous material. Flow is heavily mantled with Sunset Crater cinders and some alluvium. Maximum flow thickness is about 90 m. Flow erupted along fissure marked by reddish oxidation of the rhyodacite and by a steep high ridge. Two domes are present. The younger southeast dome contains rare xenoliths identical in lithology to the andesite porphyry flow. The higher northwest dome, ~ 600 m high, deeply gullied on north slope, porphyry unusually decomposed, possibly because of hydrothermal alteration; elsewhere domes are undissected.	Low to moderate	No restrictions noted; volcanic glass present; watch for unconsolidated deposits on slopes.	Rockfall and landslides, volcanic glass and other sharp rocks bad for trails and camping	None documented	None documented	Phenocrysts of plagioclase, orthopyroxene, amphibole, and quartz, sanidine, allanite, biotite. Volcanic glass and obsidian. Red to gray hornblende xenoliths are common.	None documented	Obsidian	Off- road vehicles unconsolidated rocks	Sanidine from porphyry of northwest dome dated at 233,000 +/- 37,000 years by K- Ar (Damon et al., 1974)	None documented

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QUATERNARY	Andesite porphyry (Qoaf); basalt cinder cones (Qtc); tuffaceous cinder cones (Qttc); basalt spatter cones or spatter ramparts (Qts); local basalt pyroclastic deposits (Qtp)	Thickness at the margins, 15 to 60 m; alkali olivine basalt and alkali-rich high-alumina basalt; cinders deeply weathered in soil zone; cones are subdued but little dissected. Ultramafic, gabbroic, granulitic, and Paleozoic sedimentary xenoliths abundant in many cones; flows undissected, blocky; includes breached spatter rampart and flow. Other units consist of interbedded tuff and alkali olivine basalt or high-alumina basalt cinders. Fragments of ultramafic rocks, gabbros, granulites, and Paleozoic sedimentary rocks are included in the tuff, which, as in the tuff rings, consists of phenocrysts or xenocrysts in a palagonitic matrix; pyroclastic deposits associated with nearby cinder cones; commonly red, hummocky, brown soil in upper part with cinder lag on surface.	Low to moderate	Unconsolidated material may be unstable for foundations, especially if on slope; varying permeability may pose a challenge to waste facility development.	Rockfall and landslides; some slumping on newly developed soils	None documented	None documented	Phenocrysts of plagioclase, olivine, orthopyroxene amphibole, apatite, clinopyroxene, biotite, rare quartz and alkali feldspar; abundant xenoliths of hornblende & andesite; some brown volcanic glass.	None documented	None documented	Off-road vehicles unconsolidated rocks	Flows and cones comparable in age to the Tappan flow of SP Mountain quad. (Ulrich and Bailey, 1974); K-Ar age of 0.51 +/- 0.08 m.y.	None documented
PLEISTOCENE	Basalt flows (Qtb), basaltic andesite cinder cones (Qtac); basaltic andesite flow (Qta); basaltic andesite porphyry dome of vent 91 (Qrad)	Largely alkali olivine basalt; some alkali-rich high-alumina basalt. Ultramafic, gabbroic, granulitic, and Paleozoic sedimentary xenoliths present in many flows; nonporphyritic to porphyritic; flow margins, 1 to 60 m thick, generally well defined and undissected; upper surfaces of the flows somewhat subdued by weathering and accumulation of alluvial or pyroclastic mantles; includes subordinate spatter and weathered cinders and spatter. Similar but highly oxidized rock forms spatter rampart; flow, similar to the dome, breached both dome and spatter rampart.	Moderate	No restrictions noted, volcanic glass present, locally exposed.	Rockfall and landslides	None documented	None documented	Sparse to abundant phenocrysts of olivine, clinopyroxene, and plagioclase, with occasional quartz	None documented	None documented	Off-road vehicles; unconsolidated rocks	A K-Ar age of 0.67 +/- 0.10 m.y. [Damon, Shafiquillah, and Leventhal, (1974, p 227)] for basalt flow from vent 171,	None documented
PLEISTOCENE	Tuff ring deposits (Qt)	Poorly sorted, well-bedded tuff containing fine-grained quartz and possibly derived from Coconino Sandstone; crystals or fragments, all in a palagonitic matrix; includes tuff deposits from an unidentified vent in SE corner of mapped area.	Low	No restrictions noted, locally exposed.	Crystal fragments	None documented	None documented	crystals of plagioclase, clinopyroxene, and olivine	None documented	None documented	Off-road vehicles; unconsolidated rocks	Tuff rings younger than Woodhouse-age flows, older than associated Tappan-age cones and flows.	None documented
QUATERNARY / TERTIARY	Basalt spatter and cinder cone (QTwc); basalt flows (QTsb), San Francisco Mountain Volcanic Center andesite flows (QTa)	Basalt spatter and cinder cone material of vent 520; Composition is alkali olivine basalt and minor alkali-rich high-alumina basalt; commonly cap mesas. Phenocrysts of olivine, clinopyroxene, and plagioclase occur in a fine- to medium-grained matrix of the same minerals, opaque oxides, and residuum; gabbro xenoliths occasionally present. Upper flow surfaces commonly quite flat; thickness at flow margins to 15 m. Locally mantled by thin rhyolitic pumice deposit; some groundmass of black, brown, or gray glass. Andesite flow surface heavily mantled with alluvium; thickness at the flow margins 6 to 30 m in mapped area.	Moderate	Unconsolidated material may be unstable for foundations, especially if on a slope; varying permeability may be problem to waste facility development.	Rockfall and landslides	None documented	None documented	Phenocrysts of olivine, clinopyroxene, and plagioclase, volcanic glass groundmass common	None documented	Obsidian	Off-road vehicles unconsolidated rocks	K-Ar ages of basalt flows of Woodhouse age range from approximately 0.8 to 3.0 m.y. (Damon and others, 1974)	None documented

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PERMIAN / TRIASSIC	Sedimentary rocks of Triassic and Permian Age, (TRPs)	Sandy dolomitic limestone and minor sandstone and siltstone of the Permian Kaibab Limestone and red sandstone with minor shale and conglomerate of the Triassic Moenkopi Formation, undivided. Includes the Permian Coconino Sandstone and Toroweap Formation in the Little Colorado River valley north of Grand Falls and in a deep canyon north of Doney Crater (vent 80). Most of the mesa- capping basalt flows of Woodhouse age (QTwb) rest on Moenkopi sandstone, as do many of the older terrace gravels (Qig). Locally includes unmapped alluvial deposits and some mantling pyroclastic materials.	Moderate to high	Rockfall potential, avoid highly fractured rocks of these units; limestone may be too permeable for waste facilities. No other restrictions documented	Rockfall and landslides	Few in SUCR; outside, Kaibab Ls.: fragments of: bryozoans, brachiopods, gastropods, bivalves, and crinoids; brachiopods, gastropods, bivalves, worm burrows, and ammonites found in Sinbad Ls. member of Moenkopi; Lingula sp. Only fossil found in Moenkopi outside Sinbad Ls.; vertebrate tracks in Torrey member of Moenkopi (Santucci, 2000).	Chert for tool making; clay for building mortar	None documented	High, in Kaibab limestone. Dissolved fissures connect to underground networks, some resulting in blowholes.	Limestone and building materials	Caving, if karst is present; climbing possible on Moenkopi rocks	Tectonic correlation with other formations on Colorado Plateau.	Avoid blowhole areas where advanced carbonate dissolution occurred.